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# Resource Notes-Summer 1986

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Vol. 1, No. 2

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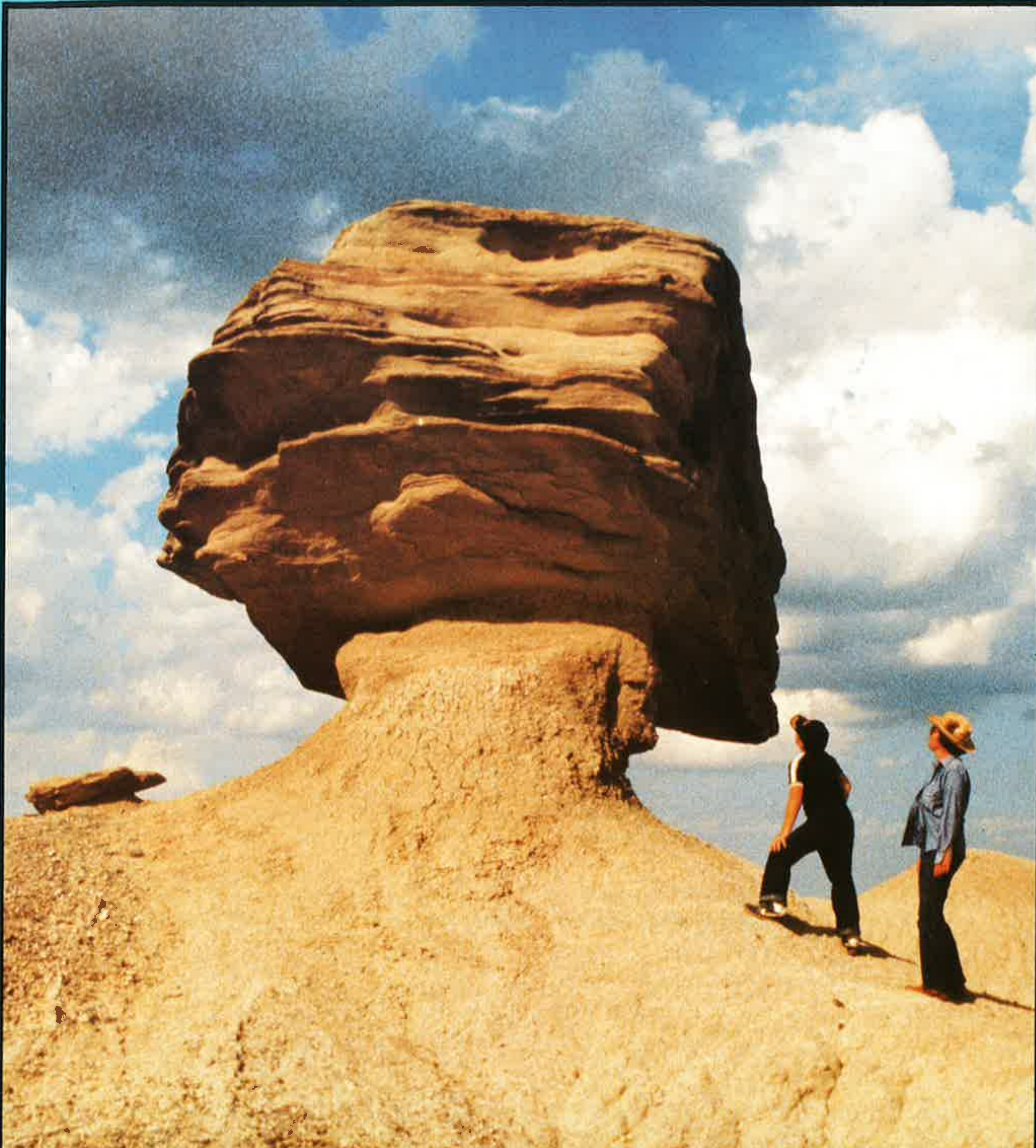

The newsletter of the Conservation and Survey Division

# A Focus on the Panhandle: Its Diversity Is Fascinating, Its History Instructive

The focus in this issue of Resource Notes is the division's activity in the Panhandle of Nebraska. If I had to choose my favorite part of the midcontinent, it would be the Panhandle. The Panhandle probably has the most diverse agricultural and natural-resource base in Nebraska. Its geologic history is fascinating, as are its paleontological, archeological and human histories. The scenery and the landforms range from the pine forests of the Pine Ridge and Wildcat Ridge areas to the Sand Hills and lakes of Sheridan and Garden counties. And in between is the Shortgrass Prairie with its broad, open spaces grazed by antelope and cattle and the valleys of the North Platte and Niobrara rivers, as well as Lodgepole and Pumpkin (Seed) creeks. Further diversity is provided by the White River-Hat Creek drainage basin to the northwest with its clay hills, badlands topography and Dakota Prairie.

Other features that set the Panhandle apart from the rest of the state are aridity and land altitude. Both affect agriculture. The mean annual precipitation increases west to east from about 15 inches to 18 inches. The altitude above mean sea level in the tablelands ranges from about 3,600 feet in the east to more than one mile in the southwest corner and to nearly that northwest of Harrison in Sioux County.

Courthouse Rock, Chimney Rock, Scotts Bluff and other prominent features were important landmarks on the Mormon Trail and Pony Express Route, and, with the addition of Ash Hollow, on the famous Oregon Trail. Even today, who can fail to thrill at the sight of Chimney Rock, particularly when seen silhouetted by floodlight at night?

To help in understanding this region, CSD has published a number of geologic reports, maps and educational circulars describing the geology and other natural resources of the Panhandle. Two popular educational circulars are the "Geologic History of Scotts Bluff National Monument" ($1.00) and the "Geologic History of Ash Hollow Park" ($2.00). And recently published and featured in this issue is a comprehensive report on its ancient landforms and historical geology, "Cenozoic Paleogeography of Western Nebraska," Reprint Series No. 52 ($1.00).

Some of the fascination of the Panhandle is revealed by a listing of people, place names and features. Among well and lesser known people are Crazy Horse, Red Cloud, Dull Knife, Old Jules, Mari Sandoz, N.H. Darton, General Crook, Harold Cook, Jim Bridger and Hiram Scott. In addition, other famous and intriguing features include Soldiers Creek, Fort Robinson, Sowbelly Canyon, Beaver Wall, the potash lakes of World War I fame, Mitchell Pass and Roubadeau Pass, Stage Coach Hill, Point of Rocks, Crescent Lake and Blue Creek. Features and names well known to geologists include the Brule and Chadron formations of the White River Group, Dakota Sandstone, Chadron Arch, Denver Basin, Crow Butte, Whalen Fault and the Mary Egging No. 1 (the first producing oil well in the Panhandle in 1949). Vertebrate paleontologists and fossil buffs are well versed in these noteworthy finds: *Daemonelix* (or Devil's Corkscrew), Oreodont, Titantothere, *Dionohyus* (a large fossil hog), *Gigantocamelus* (world's largest giant camel), and *Castoroides* (a large fossil beaver), some from University and Carnegie hills of the renowned Agate Springs fossil beds and others from other Panhandle locations.

The University of Nebraska has had a major presence in the Panhandle since the late 1800s. Geologic, paleontological and water-resource studies were carried on under Dr. E.H. Barbour's direction as state geologist from the late 1800s to the time CSD was created in 1921. The University of Nebraska State Museum maintained a major emphasis in the Panhandle under Dr. C.B. Schultz, and that involvement has continued to date. Soils mapping, geologic mapping, water-resource investigations and some biological and forestry studies were initiated or expanded by CSD under Dr. G.E. Condra and E.C. Reed. Oil and gas discoveries in 1949 led to greatly expanded subsurface interpretation and mapping under Reed's direction. CSD was responsible for regulation of the oil and gas industry, and an office was established at Sidney in the early 1950s; the industry is now regulated by the Nebraska Oil and Gas Commission, still headquartered in Sidney.

In 1973, the Panhandle Resource Conservation Development and Planning Council urged Chancellor James H. Zumberge to establish a CSD field office in Scottsbluff. Vernon Souders was named to head the office. Mr. Souders developed an active research and service presence for CSD. He worked closely with the three Panhandle natural resources districts, and several projects were wholly or partially funded by them. The office was moved to the J.G. Elliot facility when it was acquired by the university and occupied by the Panhandle Research and Extension Center. Mr. Souders was transferred to Lincoln in 1982, and Warren Barrash now fills the position. Research and data collection was greatly enhanced in 1980 by the creation of a water scientist position, first filled by Jeff Gottula and then by Pat Hegarty in 1984 and mostly supported by the three Panhandle NRDs.

**Vincent H. Dreeszen**
**Director, Conservation and Survey Division**

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*On the front cover: Sandstone with siltstone supporting pedestal, White River Group (Oligocene), Toadstool Park, Sioux County, Nebraska.*
R. F. Diffendal, CSD.

*On the back cover: Brule Formation (Oligocene) outcrop in roadcut reveals fractures that may be similar to those that yield water when the formation is used as an aquifer.*
Warren Barrash, CSD.

# The Brule as an Aquifer: Investigating the Fracture Zones

by Charles Flowerday

**The natural resources districts in the southern half of** the Nebraska Panhandle—and the South Platte NRD in particular—are now in a better position to plan for effective management of their groundwater and to address the area's groundwater-quality problems because of an aquifer study by a University of Nebraska groundwater geologist.

Warren Barrash, research hydrogeologist with the NU Conservation and Survey Division, said that he was interested in studying the Brule Formation because problems with the Brule were longstanding in the southern Panhandle, where the formation is an important aquifer. Many of these problems stem from the Brule's unique properties as an aquifer. It yields water from fractures in the rocks rather than from pore spaces in or between the grains, as with the sand and gravel aquifers that hold much of the state's groundwater.

**"Everyone noted that the Brule's properties were not uniform. Rather, it's productive where fracture zones and other kinds of voids exist. Nobody was too sure what was the genetic link between the unit and the formation of these secondary permeability zones. But the zones are out there in patches. If you hit them, you can get a highly productive well; if you don't, you're out of luck. And in some cases, hitting them or missing them might be a matter of a few feet."**

**—Barrash**

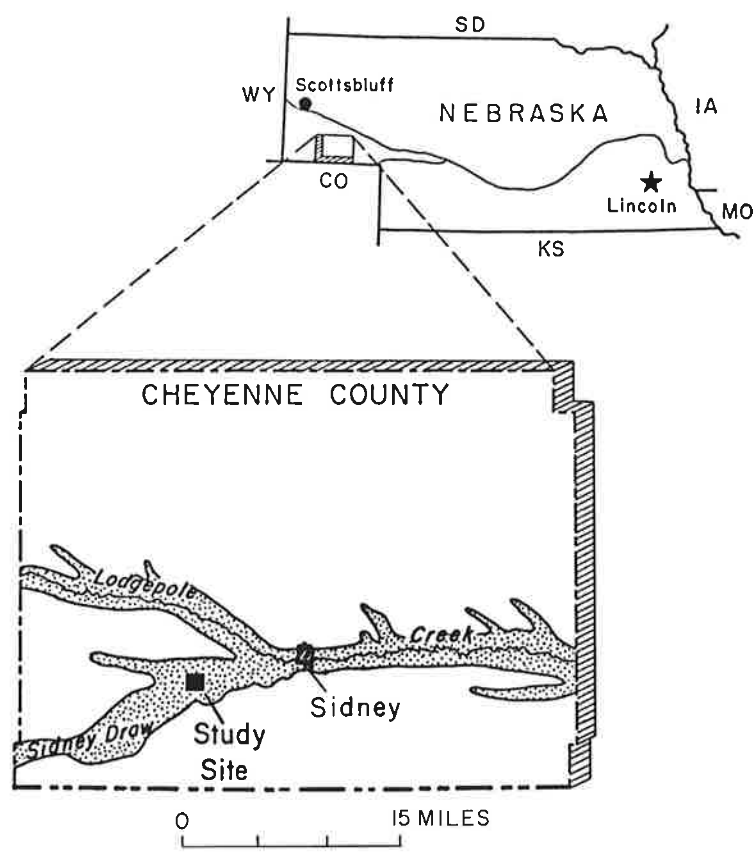
Intensive irrigation development of the Brule occurred during the 1960s and 1970s, Barrash said, scattering more than 500 irrigation wells across the Panhandle's southern half. In addition, the Brule is a source of municipal water supply for Sidney and a few nearby small towns.

Long-term water-level declines had been observed in the area since the late 1970s, said Marlan Ferguson, manager of the South Platte NRD. These observations led to hearings before the NRD's task force committee on the possible establishment of a groundwater-control area in the southern Panhandle. After the hearings, the committee recommended that more research be conducted on how the Brule responds as an aquifer, Ferguson said. In addition, when the Nebraska State Legislature required the state's NRDs to formulate groundwater management plans, the NRD's board wasn't able to estimate how long it wanted its groundwater to last—a requirement of the state water-planning process—because no one knew enough about one of the main aquifers, the Brule.

"Everyone noted that the Brule's properties were not uniform," Barrash explained. "Rather, it's productive where fracture zones and other kinds of voids exist. Nobody was too sure what was the genetic link between the unit and the formation of these secondary permeability zones. But the zones are out there in patches. If you hit them, you can get a highly productive well; if you don't, you're out of luck. And in some cases, hitting them or missing them might be a matter of a few feet."

Because of long-term and seasonal supply problems, as well as water-quality problems, the NRD contracted with CSD to have Barrash develop a quantitative interpretation of the hydraulic behavior of the Brule. The study also served as his doctoral thesis in geology at the University of Idaho. Barrash received his Ph.D. in August.

He chose a study site in the Sidney Draw area—about 7 miles west of Sidney—because many irrigation wells and oil and gas tests had already been drilled there. Also, the main fracture zone was relatively shallow, and since the draw was dry, there were no stream-aquifer relationships to worry about, he said. The site of his investigation was also in the area of the greatest water-level declines, he added.




With the cooperation of Phyllis Baird, landowner where the drilling took place, Barrash and an interesting assortment of technicians and scientists began the first of two summers of field work in 1984. Initial testing involved controlled sampling of the Brule to determine the vertical sequence of rock types and the lateral continuity of this sequence. Sample materials were then analyzed for permeability without examining secondary effects such as the fracture zones, he said. Then investigators began to test the hydraulic behavior of the Brule on successively larger scales, taking into account the aquifer, the fracture system and any other secondary permeability features.

Setting up and monitoring a pumping well and 12 observation wells during an 8-day pump test is no small chore, Barrash explained. Therefore, the CSD scientists and technicians were assisted at various times by members of the U.S. Geological Survey's Borehole Geophysics research group from Denver, by technicians from the Agricultural Research Division at the NU Panhandle Research and Extension Center at Scottsbluff, by staff of the South Platte NRD, by city employees of Sidney and by a few Sidney high school students.

Whereas modeling most fractured aquifers involves some very complex ''data-smoothing'' techniques, Barrash said, the density and interconnectedness of the Brule's fractures allowed him to treat the fracture zone as an ''equivalent porous medium,'' meaning that it responds more or less

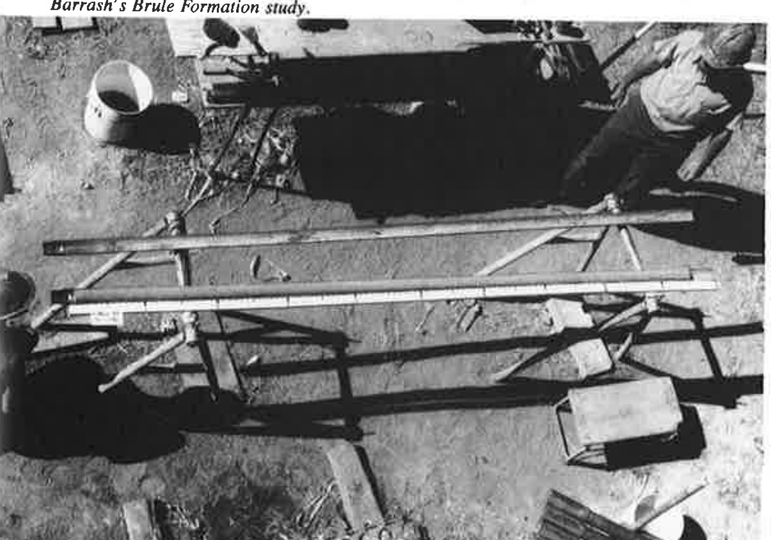
Warren Barrash

*A member of the Kansas Geological Survey assists CSD in seismic-reflection studies of the Brule Formation near Sidney. He is shooting a padded 3.06 rifle into the ground to create acoustic waves for seismic testing that will help researchers profile the subsurface.*

like an equivalent layer of sand or gravel.

While the fracture zone is where a well needs to tap groundwater, the area above and below is equally important, the CSD researcher said. If the fracture zone is like a pipe conducting water stored in a water tower, the unfractured material above and below represents the tank. The unfrac-

*An overhead view (taken from the drilling rig) of core samples examined during Barrash's Brule Formation study.*



Warren Barrash

Conservation and Survey

*Jeremy Dillon and Warren Barrash, both of CSD, examine core samples during Barrash's study of the Brule Formation near Sidney.*

tured material conducts water more easily vertically than horizontally, in part because of openings from fossil root traces and burrowing insects, he explained.

What this means for groundwater management is that no matter how thick the saturated Brule material that a well taps, if a crucial saturated thickness is not maintained above the fracture zone, the well's capacity to draw water is reduced considerably, Barrash said. Assuming that the unfractured material participates in the aquifer system allowed him to explain several of the past management problems, he added. Some of these were:

—Abandoned wells near working wells—the abandoned well may have tapped a fracture zone that has been dewatered by long-term water-level declines.

—Wells that dramatically lose productivity during the irrigation season—as pumping continues, the material above and in the fracture zone becomes de-watered, thereby severely limiting the aquifer's ability to produce water.

—Pumping in one well causing water-level declines in nearby wells right after pumping begins—if both wells tap the same fracture zone, water-level changes occur very rapidly due to the highly conductive nature of the fracture zone.

''Regarding the management implications, it would be nice to map these fractured areas out, so we can alert operators to where they're either drawing from more than one well in the fracture zone or are sharing the zone with their neighbors,'' Barrash added. Knowing the distribution and depth to these zones and the saturated thickness above a given zone will allow the operators to determine if there is an adequate saturated thickness for various cropping patterns and irrigation practices.

''That way people can, to a certain extent, manage their own resource. It would be hard to lay down a uniform code of pumping behavior because we're really dealing with a patchy distribution. It may have to be customized,'' Barrash explained.

Lastly, since nitrate problems have been discovered in Sidney and the surrounding area in a patchy pattern also, understanding the hydrologic system will help Sidney and the NRD better analyze water-quality problems.

''I think we really need to understand the behavior of the aquifer before we start pointing any fingers,'' Ferguson said. ''We're being asked to manage this resource. It's pretty complicated without knowing more about the resource. Most of the landowners know it's a limited supply. They understand there's a problem, but they haven't known why.''

# The Panhandle's Cenozoic Geography: Basis for Resource Interpretation

by Charles Flowerday

**Some contributions to the advancement of science** result from a single mind making a quantum leap to a new unified theory. Many, however, emerge slowly from a painstaking sifting of complex data by a few colleagues. While the latter may not be the stuff of which legends are made, it can lead to a sound basis for resource-management decisions, according to two University of Nebraska geologists.

Compiling a composite picture of the ancient geography of the Nebraska Panhandle wasn't glamorous work, but it has provided the framework for interpreting the present natural resources of the area, explained Jim Swinehart, research geologist with the Conservation and Survey Division of the University of Nebraska-Lincoln. Swinehart and his co-authors, CSD research hydrogeologist Vern Souders and CSD research geologists Bob Diffendal and Harold DeGraw, represent a combined total of more than 60 years of experience in the Nebraska Panhandle. And since the last attempt at a regional synthesis of the area's historical geology was made 30 years ago, they decided another synthesis should be done using all the data gathered since then.

"The guts of any attempt to inventory natural resources is a good, sound knowledge of the stratigraphy and geological history of the area," Swinehart said. Explaining their paper, "Cenozoic Paleogeography of Western Nebraska," he added that paleogeography is the study of an ancient geography. The paper is an attempt to capture a series of snapshots of an area's geologic history. And even though it's more difficult to work with a multi-author paper because it involves integrating many viewpoints, he said, the effort was worth it.

"The total information available and the additional perspectives of all that experience in the Panhandle made it quite an exciting event," he said. "It's nearly an order-of-magnitude increase in the information level."

Incorporating data from almost 11,000 oil and gas tests, thousands of registered irrigation wells, about 500 test holes drilled by CSD and cooperators such as natural resources districts, and that from outcrops and paleontological studies, the researchers have reconstructed the geography of the Panhandle during the Cenozoic Era—the last 67 million years. Their work differs significantly from the 1956 reconstruction of an NU father-and-son team, A.L. and Richard Lugn. While other workers have studied various parts of the total stratigraphic picture in the Panhandle, the CSD report is the most recent synthesis since the Lugns published their study.

Delivered at the third Rocky Mountain Paleogeography Symposium in Golden, Colo., July 1985, the paper was included in the companion volume, "Cenozoic Paleogeography of the West-Central United States," published by the conference sponsor, the Rocky Mountain Section of the Society of Economic Mineralogists and Paleontologists. Since the first 30 million years of the Cenozoic Era in western Nebraska are a period of erosion, the paper deals primarily with the period beginning about 37 million years ago.

"It is not, as might first be thought, simply a story of rivers transporting material eroded from the Rocky Mountains and depositing it on the plains. A surprisingly tremendous volume of fine volcanic debris was blown into Nebraska during the middle Cenozoic," Swinehart explained. In addition, structural features such as faults and folding have played an important role in the geologic history of the plains. Before the latest synthesis, the summary of the landscape's evolution tended to concentrate on the development of the major river systems. The Lugns only briefly mention eolian (wind-deposited) or volcaniclastic (volcanic sand and silt) debris in the formation of the Arikaree and White River groups, rock groups that, along with the Ogallala Group, make up the bedrock of most of western Nebraska, he said.

**"It is not, as might first be thought, simply a story of rivers transporting material eroded from the Rocky Mountains and depositing it on the plains. A surprisingly tremendous volume of fine volcanic debris was blown into Nebraska during the middle Cenozoic."**

**—Swinehart**

Four other accomplishments of the geologists' work have been refining the sedimentation pattern of these rock groups; delineating the trends of the major paleovalleys (ancient valleys); placing more emphasis on how folding and faulting influenced sedimentation; and determining the distribution of the Lower Whitney Ash bed and the Nonpareil Ash zone, both in the White River Group. In addition, they reported on eight superposed ash marker beds in the Ogallala Group. Additional work on ash chemistry may help to tie in this period of eolian deposition with similar ones in other western states and with major eruptions in Nevada, Utah and Idaho, explained Diffendal, who walked the area to identify the surface exposures of these ashes.

Prior to the CSD synthesis of the Panhandle's ancient geography, the role of volcanic sources in Colorado, Nevada and Utah in constructing the plains was often underrated, Swinehart said. During the middle Cenozoic period—about 32 to 18 million years ago—the plains were built primarily by a gradual accumulation of volcanic material that was then reworked by wind, he added. These eolian deposits formed mostly in a fairly arid climate, a semi-arid period sandwiched between periods that were wetter, even subtropical at times.

In all, there may be more than 50 ash beds throughout the Panhandle, Swinehart said. Looking at these ash beds and the geologic formations that surround them, the CSD scientists were able to point out a rather dramatic shift in the type of deposition that formed the plains. Understanding it requires a brief examination of the strata that formed before and after it.

"Except for the river deposits of the Chadron, the White River sediments and landscapes are overwhelmingly products of the deposition of fine-grained pyroclastic material. This material, typified by glass shards, was derived from western-source rhyolitic and andesitic volcanic centers," the paper explained. This group of sediments was initially deposited about 38 million years ago. Then, after a period of primarily river-deposited sediments lasting from about 28 to 24 million years ago, direct wind-blown and air-fall volcanic debris again spread across most of the Panhandle, the researchers said.

However, by the time the Ogallala Group sediments began forming—about 18 million years ago—the landscape had undergone a major shift in its evolution. "Widespread eolian deposition gave way to restricted alluvial (stream-deposited) deposition in valleys," the paper said.

"Depositional patterns became much more complex," Swinehart explained. "There were more stream deposits and probably more variation in climate. A warmer, more moist climate returned at times."

This transformation in volcanic activity near the beginning of the Ogallala deposition is probably related to a change in the tectonic relationships forming the North American continent, he added. At the time, a lithospheric plate under the eastern Pacific Ocean was converging with the North American plate, and the oceanic plate was being subducted. Sometime between 30 and 10 million years ago—perhaps about 20 to 18 million years ago—this subduction stopped. Such subduction, or submerging, of one plate by another frequently gives rise to volcanic eruptions and mountain building.

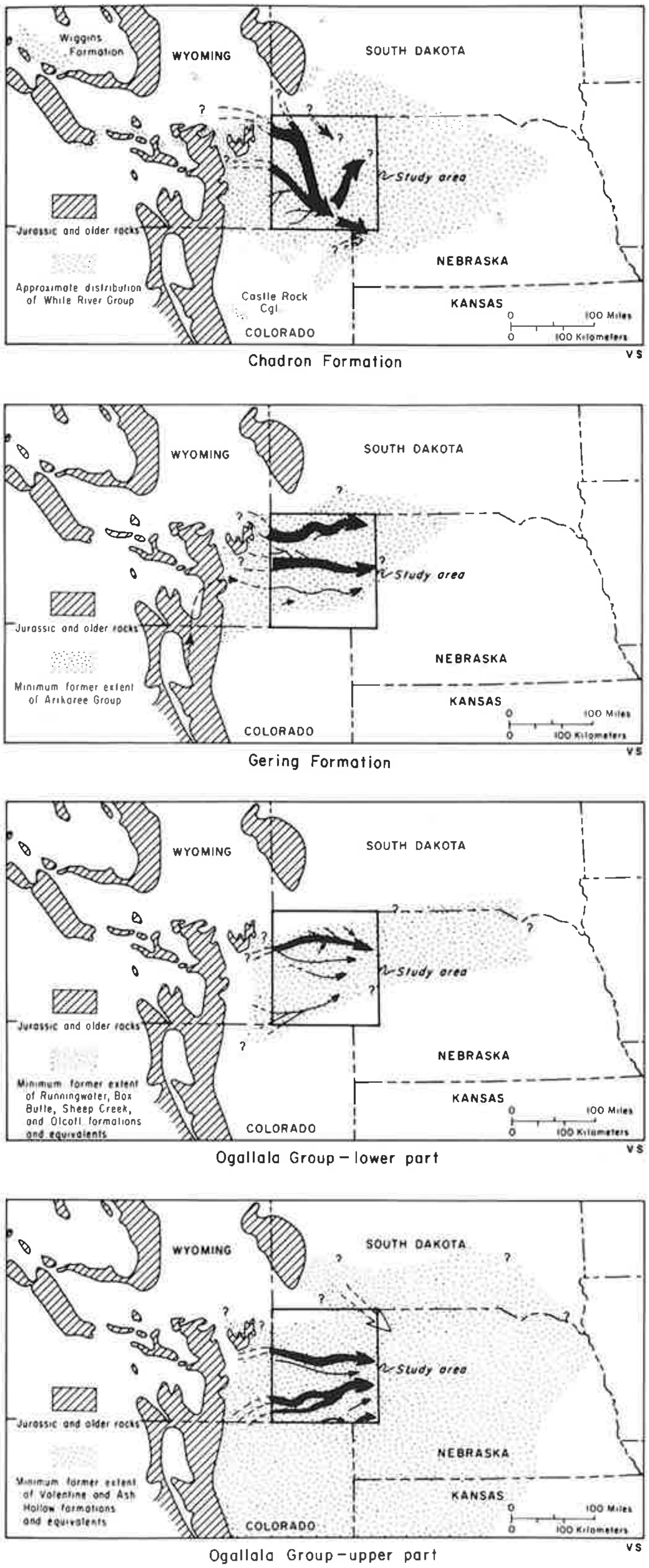
"In Nebraska and South Dakota, we get a little clearer picture because we're farther from the source of 'noise,' " Swinehart explained. "We have a chance at a better understanding of the big picture."

Another part of the big picture previously underemphasized was that played by structural changes. A considerable amount of folding and faulting has taken place since the beginning of the Cenozoic, Swinehart explained. One of the practical values of this knowledge relates to petroleum exploration. To understand the migration of oil and gas, for example, one needs to know the timing of folding and faulting in the area, he added.

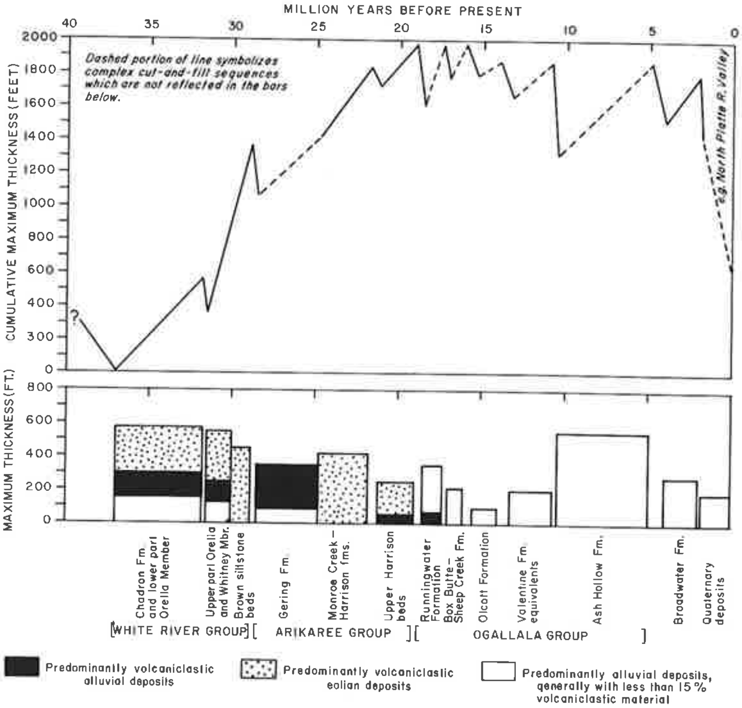
"If you cannot subtract out these later movements from earlier faults and folds that influenced oil or gas migration, then you are looking through a glass darkly," he said. Frequently, examination of ash marker beds, unconformities (major erosion) and paleosols (ancient soils) provide clues to unraveling the structural changes that have occurred in an area. These changes have influenced the ancient and present drainage patterns, and consequently, the location of groundwater supplies, as well as economic minerals such as uranium or oil and gas.

"The recent major uranium discovery (near Crawford) is in an old valley system of the White River Group. The more that is known about this ancient river deposit, the less random the drilling should have to be in the search for additional ores," Swinehart said.

Concerning the importance of structure, they said: "Generally speaking, episodic regional uplift and local adjustments took place throughout the Cenozoic and presumably are expressions of varying degrees of structural movements in the Rocky Mountains to the west." These episodes of uplift are represented on the accompanying graph, which




*Regional setting of selected Cenozoic ancient drainages.*




*Time-maximum thickness and cumulative-curve diagram for the Cenozoic of the western part of the study area. Patterns of deposition are best shown by time-sediment volume graphs but sufficiently accurate volumes for the stratigraphic intervals used here are not known.*

also shows thickness and origin of sedimentation.

While the researchers noted that every instance of downcutting is not necessarily the result of tectonic activity, they believe that structural movements, combined with pre-Ogallala volcanic activity to the west, were the main determining factors in shaping the past and present landforms of western Nebraska.

The drainage courses of the ancient streams are another part of the big picture that has undergone revision. Though the Lugns believed that the drainage patterns during the Cenozoic were only slightly different than the present ones, the CSD team reconstructed at least four different patterns that emerged before the present courses became established about 5 million years ago. Knowing the distribution of these paleovalleys frequently is a key to finding groundwater in the relatively arid Panhandle because they are generally filled with coarse material such as sand and gravel.

"For many of the questions regarding groundwater—how much groundwater is in storage, for instance—there are vastly different scenarios you can devise if you were to only use information from test drilling," he said. One needs to know how interconnected the paleovalleys are before estimating the extent of supplies, he said. The integration of subsurface and surface data can provide better answers to these questions, he added.

"We have emphasized structure because the new data show it was more important than once was thought. The Cenozoic structural features of western Nebraska are not as spectacular as those of the Rocky Mountains, but they're important enough," Swinehart explained. They've influenced sedimentation and the migrations of fluids, among other things, he said.

"The more subtle the structure, the harder it is to document," Swinehart said. "But you have to make that interplay between detailed information and regional information. Then you can come back and refine the detailed work. This has helped us sort out the history of landscape evolution in the Panhandle, where you've got complex depositional systems related to wind and related to water, and then you've got tectonic activity changing things. What you've really got is a multitude of subenvironments."

# Initial Research Instrumental to Uranium Discovery and Impact Analysis of Mining Method

by Pat Larsen

**The discovery of a world-class uranium deposit has** made western Nebraska more visible in the mineral industry, promising jobs to an economically stressed area and money for the state's general fund. But the solution-mining pilot project—begun in late July—has also caused concern among some local residents about the future quality of the area's groundwater.

While the decision to allow mining of the whole ore body hangs in the balance and rests with the Nebraska Department of Environmental Control, in evaluating the project's environmental impact, DEC will rely on preliminary technical information provided by the Conservation and Survey Division of the University of Nebraska. The division supplied initial geologic and hydrochemical data necessary to the proper development and monitoring of the pilot project.

Marvin Carlson, research geologist at the division, said that the discovery of about 30 million pounds of ore at the 80-acre Crow Butte site—about 2 miles southeast of Crawford—was announced as the largest in the western hemisphere since a big strike in Utah in the 1950s. The find may be of major importance because, if developed, it would mean the mineral industry would become a significant contributor to the state's economy. In addition, research by the division and earlier studies by the U.S. Geological Survey have shown that there is a possibility of similar deposits in other parts of the Nebraska Panhandle.

Local concern has been about 1) the possible escape, or excursion, of the mining solution from injection wells into the surrounding aquifers, 2) the possibility of mobilizing other chemical elements during the leaching of the uranium ore and 3) the potential that the ore might be recovered by strip or open-pit mining.

Since the ore lies in the sandstone of the basal Chadron Formation at a depth of about 650 feet, in-situ—meaning "in place"—recovery will be used, rather than open-pit or underground mining. The uranium will be extracted by injecting a sodium carbonate-bicarbonate or ammonium carbonate solution and air, or hydrogen peroxide, into the formation through four injection wells, Carlson explained. The uranium dissolves into the solution, and an extraction well pumps the fluid to the surface. It is then passed through an ion-exchange column, similar to a water softener, where the uranium is extracted. The remaining fluid is returned through the injection wells, he said.

The basal Chadron sandstone is underlain by the impermeable clay and silt of the Pierre Shale and is overlain by the claystones and clayey siltstones of the upper Chadron—separated from the basal Chadron by a layer of smectite, a swelling clay. The clay layers above and below the ore body are expected to contain the affected groundwater, researchers have said.

Hydrogeologist Vern Souders and geologists Harold DeGraw and Jim Swinehart, all of CSD, provided much of this geologic information to the mining company, Wyoming Fuels, and its subsidiary, Ferret Exploration, during the initial exploration of the mining site, as well as to DEC during hearings about the pilot project.

**Although one in-situ mining operation near Douglas, Wyoming, had to be shut down because mining-solution chemicals leaked into the aquifer outside the mining area, another operation in Texas apparently has been working. In-situ mining of uranium near Corpus Christi has been in operation for about 10 years and appears non-contaminating to the overlying and surrounding aquifers, Carlson said.**

Another Conservation and Survey staff member, hydrochemist Roy Spalding, led a preliminary investigation by a group of CSD scientists and a Chadron State College chemist, Arthur Struempler. They collected about 100 groundwater samples from the mining area to determine the baseline chemical constituents of the local surface water and groundwater. They also examined head values to determine local and regional groundwater flow and the configuration of the water table. In addition, estimating the residence times of various groundwaters allowed them to analyze patterns of groundwater recharge.

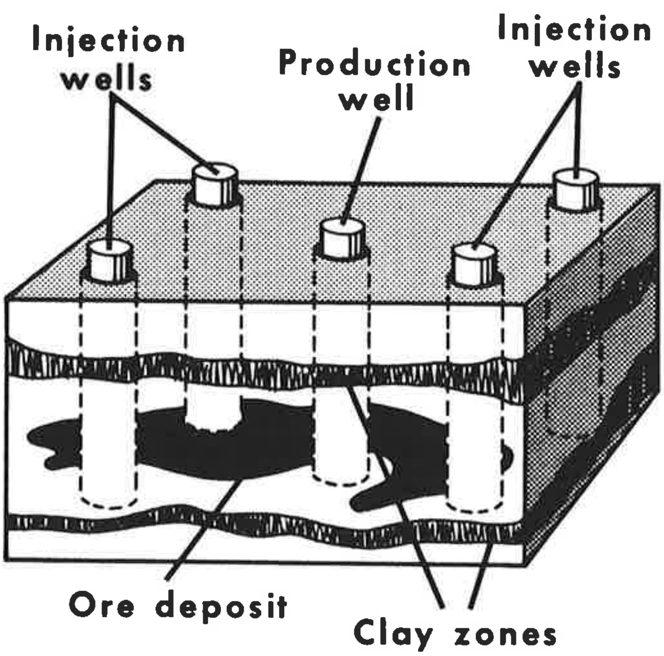
In a cooperative agreement with DEC, these division researchers and Struempler chemically characterized water units and water-bearing formations. Analyzing these waters for differences in their chemical characters should allow for detection of excursions from the ore-bearing unit, Spalding said.

During monitoring of the pilot project, scientists will be checking for any migration of affected water and mining solution through faults in the project area or any incompletely plugged test holes, which might provide connection to overlying aquifers. Faulting is not expected to cause problems since the smectite should plug the faults, according to various researchers. Carlson added that the injection wells are carefully cased to protect the overlying aquifers.

Monitoring the pilot project for excursions would involve looking for increases from baseline values in radium-226, uranium, boron, arsenic, hydrogen sulfide, sulfate and the mining solution. Monitoring personnel may also check for any changes in pH levels and for an isotopic ratio of uranium-234 to uranium-238 of about 1, Spalding said. He also pointed out that the natural water in the basal Chadron Formation in the mining area is of questionable quality for human consumption. It has relatively high levels of dissolved solids, sodium, radium-226 and hydrogen sulfide, he noted. However, it has been used for livestock watering and irrigating gardens, he added.

Although one in-situ mining operation near Douglas, Wyoming, had to be shut down because mining-solution chemicals leaked into the aquifer outside the mining area, another operation in Texas apparently has been working. In-situ mining of uranium near Corpus Christi has been in operation for about 10 years and appears non-contaminating to the overlying and surrounding aquifers, Carlson said.

Concerning the value of the discovery, Carlson said that currently there is an abundance of uranium and prices have been dropping. But most uranium is sold through long-term contracts, which bring about one-third more than market value. Demand is expected to increase in the late 1980s and early 1990s, mining officials have said. The value of the ore body being developed has been estimated at more than $600 million.




*Cross section and schematic diagram of solution mining for uranium, showing wells, ore and clay layers.*

The Crow Butte pilot project will take about a year, and about another year will be needed to restore the water quality in the basal Chadron, Carlson explained. Then another permit will be needed to mine uranium commercially. Before this, the pilot-project data will be evaluated, including an examination of the quality of the restored basal Chadron water, and more hearings will be conducted at that time. The division expects to continue to be involved both in the discovery of new mineral resources, as well as in the procedures required for proper development, Carlson added.

# *A Look at Oil and Gas in Nebraska:*

## More Exploration Likely in Panhandle and Richardson County

**Although the current world oil glut has cut oil and** gas exploration in Nebraska by about half during the first half of 1986 compared with the same period last year, when oil prices rise to a more market-driven level—around $17-$20 a barrel—oil and gas exploration in the state will increase, particularly in the deeper rocks of the Panhandle's Denver-Julesberg Basin and probably in extreme southeastern Nebraska.

That's the assessment of Ray Burchett, research geologist with the Conservation and Survey Division of the University of Nebraska-Lincoln.

According to the Nebraska Oil and Gas Commission in Sidney, 77 drilling permits had been issued through June, compared with 149 during the first half of last year. Most this year were wildcats, and most of this activity is in the southern Panhandle, although some drilling is in southwestern Nebraska.

Until prices rise, drilling is going on only as the expected volume from a given field can justify it, the CSD researcher said. Drilling on many deeper wells has been held up pending better prices, he added.

A return to equilibrium in the oil market should affect Nebraska's economy because of a renewed interest in oil and gas in the Panhandle since 1980, when Diamond Shamrock Corp. opened the Amazon field in Cheyenne County. This well pumped 115 barrels a day from 7,062-76 feet and from 7,086-94 feet. The deepest producer from the Denver Basin at the time, it signaled a search for oil and gas in the Paleozoic—primarily the Pennsylvanian and Permian—rocks. Then during 1985 and 1986, before recent sinking prices, three new discoveries in the southern Panhandle and one in Sioux County also showed encouraging results from deeper strata than had shown promise prior to 1980. Previously, most of the exploration in the Denver Basin had been in the Cretaceous rocks. But these strata have been contributing increasingly less oil since the early 1960s.

"Since 1980, there's been an added incentive to look for the deeper deposits. There had been some luck in these rocks in South Dakota," Burchett said. "Any time you open a new reservoir, there's some excitement."

Another area creating some excitement in the oil industry—indicated by leasing and limited test drilling before prices declined—has been along the Mid-Continent Rift System, which runs northeast to southwest through the southeastern part of Nebraska, Burchett said. Rift systems in other parts of the world have produced oil, but none in the U.S. have generated interest until the current play, he added. This drilling mostly has been curtailed—also due to depressed prices—but it has been some of the deepest test drilling in the U.S., exploring rarely searched rocks of Precambrian age. Until recently, they were thought to be entirely igneous, not the more porous sedimentary material that might contain oil.

Burchett, who keeps inventories on mineral operations in Nebraska for CSD, reviews the history of oil and gas exploration in the state in the accompanying article.

# Oil and Gas Exploration in Nebraska

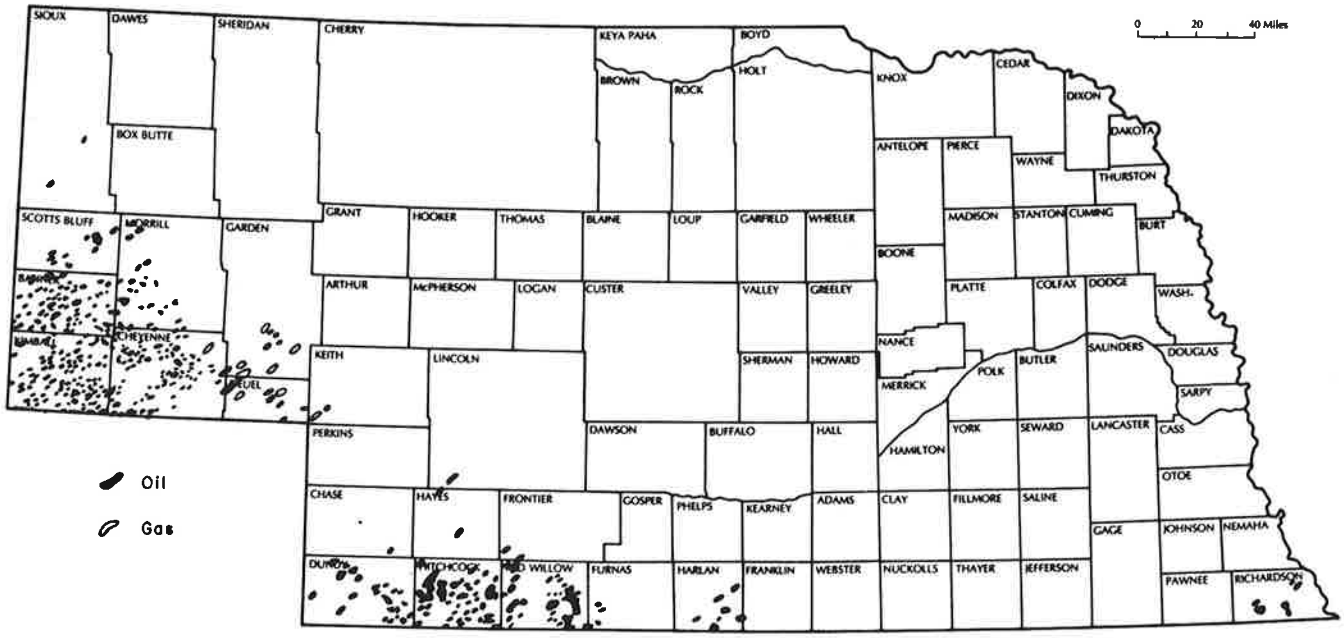
by Ray Burchett
Research Geologist, CSD

**Oil was discovered in Nebraska in November 1939.** Total cumulative production in the state as of January 1, 1986, was 415,778,463 barrels. According to the Nebraska Oil and Gas Commission, oil production in 1985 from 2,060 active wells was 6,942,502 barrels, or a daily average of 19,020 barrels. Total cumulative gas production in Nebraska as of January 1, 1986, was 274,491,984,000 cubic feet, and gas production in 1985 from 19 active wells was 1,944,569,000 cubic feet. Currently active oil and gas fields are shown on the accompanying map.

Nebraska can be subdivided into several major geologic and tectonic provinces that affect the occurrence of oil and gas accumulation in rocks. The Panhandle and southwestern parts of the state lie within the Denver-Julesburg Basin. The Chadron Arch cuts across the western part of the state in a northwest-southeast direction and joins the Cambridge Arch in southwestern Nebraska. The Kennedy Basin, a small basin in north-central Nebraska, is limited in extent on the west by the Chadron Arch and on the east by the northeast-southwest trending Siouxana Arch. The Central Nebraska Basin comprises much of central and some of eastern Nebraska. This basin is separated from the Forest City Basin in extreme southeastern Nebraska by two major uplifts—the Eastern Nebraska and the Nemaha. Together, these two uplift areas overlie an older structural system called the Midcontinent Rift System.

The Falls City Field resulted from the 1939 oil discovery in Richardson County of extreme southeastern Nebraska. Still producing, this field is in the Forest City Basin, which includes northeastern Kansas, northwestern Missouri and southwestern Iowa. Currently oil is being produced also from small fields in the Kansas and Missouri parts of the basin, as well as southeastern Nebraska.

Discovery of oil in Cheyenne County, located in the southern part of Nebraska's Panhandle, occurred in June 1949, 10 years after the Forest City Basin find. The resulting development of the Gurley Field opened the big Denver-Julesburg Basin play in the Cretaceous "D" and "J" sands. For a time this basin accounted for a major part of Nebraska's oil and gas production and reserves. However, pro-



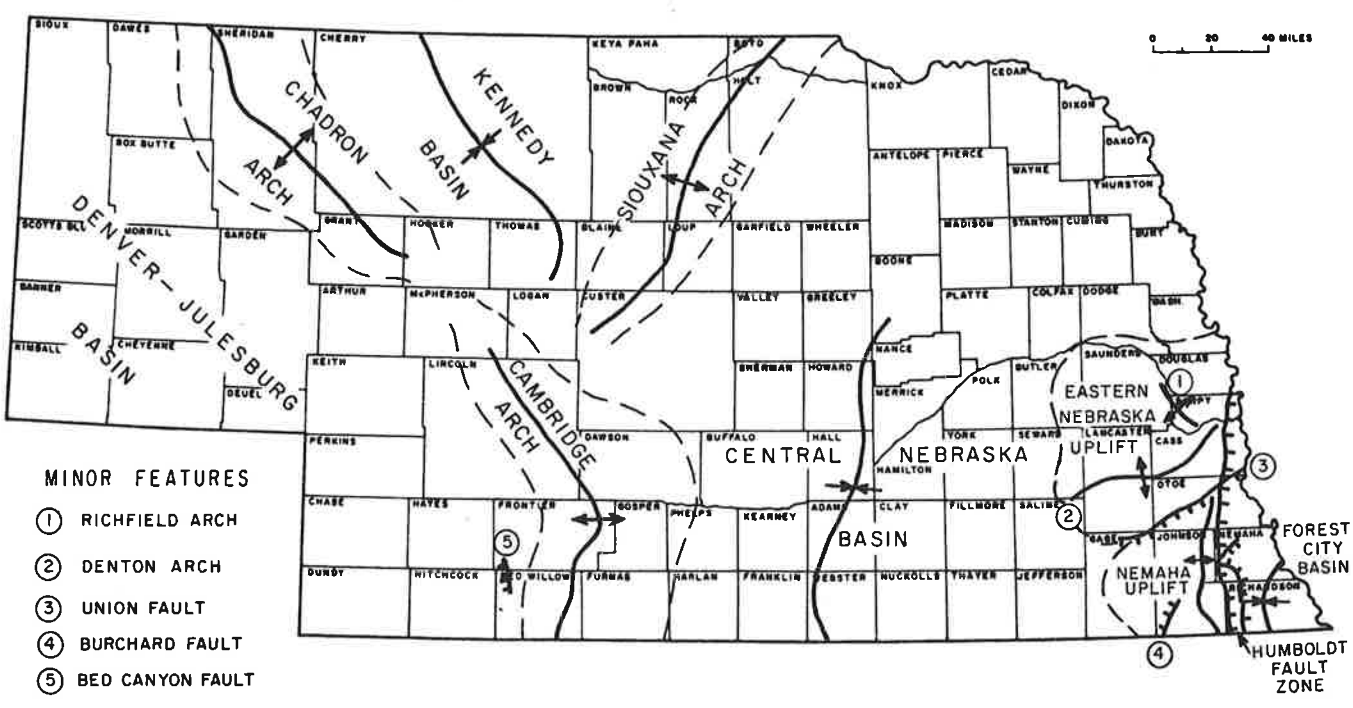

*Location of active oil and gas fields in Nebraska, as of July 1, 1986*

duction from the fields in the Denver-Julesburg Basin has declined during the last 25 years and, concurrent with the decline, production from the Cambridge Arch area of southwestern Nebraska has increased.

Oil in limestones of Pennsylvanian age was discovered in 1956 along the western flank of the Cambridge Arch in Hitchcock and Red Willow counties of southwestern Nebraska. The lease play generated by this discovery extended throughout most of the Chadron-Cambridge Arch area. Many oil and gas tests were drilled in southwestern Nebraska but without much success. A small number of Pennsylvanian age discoveries during 1957-59 and the discovery of Permian limestone production in Dundy County during 1957 failed to encourage significant further exploration programs until the discoveries that led to development of the Reiher Field in Hitchcock County and the Ackman Field in Red Willow County.

The most important oil discovery in the 1960s occurred in Red Willow County. The producing horizon was the "basal sand" of Pennsylvanian age. Completion of the discovery well opened the Sleepy Hollow Field, which was the state's highest-producing field in 1961. Daily average production from that field then was about 14,300 barrels. Production of oil from Pennsylvanian-age rocks reached its peak in 1962 at about 7.3 million barrels. Production of oil in the state during 1962 totaled 24,893,777 barrels and was the highest for any year in Nebraska history.

Interest in southwestern Nebraska was renewed in 1979




*Principal structural features of Nebraska* with completion of discovery wells in the Boevau Canyon Field in northwestern Hitchcock County. Production there is largely from Pennsylvanian rocks—Lansing-Kansas City limestones and the Cherokee Sandstone—and a minor amount is from the Cambrian "Reagan Sandstone."

In the Forest City Basin, oil is obtained mostly from producing horizons in rocks of Devonian (Hunton Dolomite) and Ordovician (Viola Dolomite and St. Peter Sandstone) age.

Most of Nebraska's current production is from Pennsylvanian rocks in southwestern Nebraska. However, in the Panhandle area, the "D" and "J" sands in the Cretaceous Dakota Group still are producing oil and gas, the "J" being the larger oil producer. Some minor amounts of gas are being produced in the Panhandle and in southwestern Nebraska from the Niobrara Chalk of Cretaceous age. Along the west flank of the Cambridge Arch, oil is being produced from limestones of the Pennsylvanian Lansing-Kansas City limestones, the "basal Pennsylvanian sand" and near the top and along the west flank of the Cambridge Arch from rocks of the Pennsylvanian Cherokee Sandstone. Oil is also being produced from the Lansing-Kansas City rocks along the eastern flank of the Cambridge Arch. Minor amounts of oil are being produced along the flanks of the Cambridge Arch in southwestern Nebraska from the Foraker Limestone of Early Permian age and from the Cambrian "Reagan Sand." New deep discoveries in the Panhandle are producing oil from rocks of both Permian and Pennsylvanian age. In the Central Nebraska Basin oil production is from rocks of Lansing-Kansas City age and in the Forest City Basin is mainly from the Devonian Hunton Dolomite with minor amounts being produced from the Ordovician Viola Dolomite and St. Peter Sandstone.

Exploration for new production of oil and gas in Nebraska is centered on the eastern part of the state and the Panhandle.

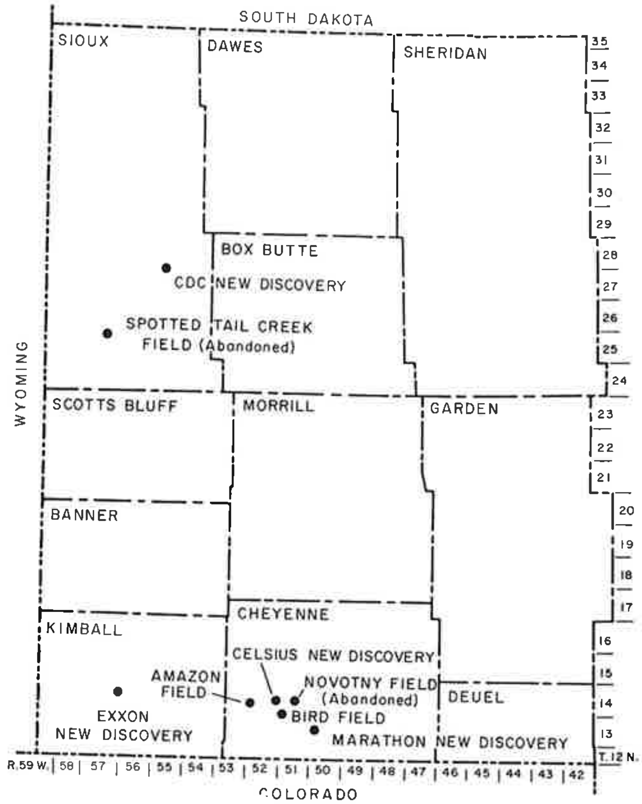
The eastern Nebraska exploration is associated with the Midcontinent Rift System and the adjacent Forest City Basin. This rift system extends from northeastern Kansas across southeastern Nebraska and western Iowa and continues on across Minnesota, northwestern Wisconsin and Michigan's Upper Peninsula. The finding of oil seeps in Precambrian sedimentary rocks associated with the rift in Wisconsin and Michigan has prompted several major and many minor independent companies to lease 6 to 7 million acres along this feature. The leases give these companies the legal rights to explore for oil and to produce it if found. To explore the potential of Precambrian rocks under Washington County, Kansas—adjacent to Jefferson County—Texaco Inc. drilled a well in 1984 to a depth of 11,300 feet. However, detailed information on this hole is being kept confidential until 1987. Plans made by Pan-American Petroleum, a subsidiary of Amoco Production, to drill a 15,000-foot test in early 1986 in western Carroll County, Iowa, were delayed because of depressed oil prices.

Panhandle exploration for deeper oil has been mostly in southwestern Cheyenne County but has included some sites in Banner, Kimball and Sioux counties. Information on recent developments is summarized as follows:

*Cheyenne County*

1980. Diamond Shamrock Oil Co. completed 1 McMillan in NE1/4 NE1/4 sec. 28, T. 14 N, R. 52 W to open the Amazon field. The well initially pumped 115 bbls of oil per day from the upper part of the Virgil Series of Pennsylvanian age.

1984. Wexpro Co. completed 1-23 Lyngholm in SE1/4 SE1/4 sec. 23, T. 14 N., R. 51 W. to open the Novotny Field. Initial production was 45 bbls of oil and 106 bbls of water from rocks of Lower Permian age. The well was abandoned.




*Location of oil fields producing from rocks of Permian and Pennsylvanian ages in the Nebraska Panhandle area.*

1985. Celsius Energy Co. and Sun Exploration and Production Co. completed 1-33 Livingston in SE1/4 SE1/4 sec. 33, T. 14 N., R. 51 W. to open the Bird Field. The well pumped 180 bbls of oil per day from rocks of Pennsylvanian age. The same companies also drilled 4-1 Bird in the NW1/4 NE1/2 sec. 4,T. 13 N., R. 51 W. Oil production from the two wells totaled nearly 90,000 bbls in 1985.

1985. Kyle R. Miller set production casing on the 2 Walker, NE SW sec. 23, T. 13 N., R. 52 W. Evaluation of the well is still taking place.

1985. Marathon Oil Co. set pipe on 1 State in NW1/4 SW1/4 sec. 16, T. 13 N., R. 50 W. This well was completed originally in 1950 as a gas discovery in the Dakota Sandstone and then was deepened and completed as an oil well in the Permian rocks.

1985. Celsius Energy Co. and Hunt Oil Co. completed 20-1 Mathewson in NW1/4 NE1/4 sec. 20, T. 14 N., R. 51 W. Initial production from rocks of Pennsylvanian age was 344 bbls per day.

1986. Celsius Energy Co. and Sun Exploration and Production Co. completed the third well in the Bird Field. The 3-1 McMillan, NW NW sec. 3, T. 13 N., R. 51 W., is reportedly swabbing more than 500 bbls per day from the Pennsylvanian rocks.

1986. Donald C. Slawson Oil Producer abandoned a wildcat (1-13 Cliff Farms, SE NE sec. 13, T. 14 N., R. 52 W.), which blew out in the Permian rocks. A flow of 2 to 5 million cu ft of gas (approximately 95 percent nitrogen) per day was estimated by the company. Slawson has received a permit to drill a twin well to the blowout.

*Kimball County*

1986. Exxon Corp. completed 1 James Koenig in NW1/4 NW1/4 sec. 17, T. 14 N., R. 56 W. Daily production of 35 bbls of oil and 11 bbls of water was from rocks of Permian age.

*Sioux County*

1984. Bird Oil Corp. completed 11-16 Bird-Corman in SE1/4 SE1/4 sec. 1, T. 25 N., R. 56 W. and opened the Spotted Tail Creek Field. This well produced a total of 571 bbls of oil and 784,000 cu ft of gas from rocks of Pennsylvanian age before the well casing collapsed.

1986. CDC Producing Co. has completed a remote wildcat in southeastern Sioux County. The 13-3 Murphy SW SW sec. 3, T. 27 N., R. 54 W. pumped seven bbls of oil and 44 bbls of water per day from rocks of Pennsylvanian age.

Thicker Cover Due to More Moist Microclimate

# Pine Ridge Soil Development Better on North Slopes

by Jeff Green
*Research Soil Scientist, CSD*

**Soils on north-facing slopes in Nebraska's Pine Ridge** area are better developed and have a deeper profile than soils on south-facing slopes. Correspondingly, the density of the dominant member of the Pine Ridge plant community—the ponderosa pine—is much greater on the north slopes than on the south-facing slopes.

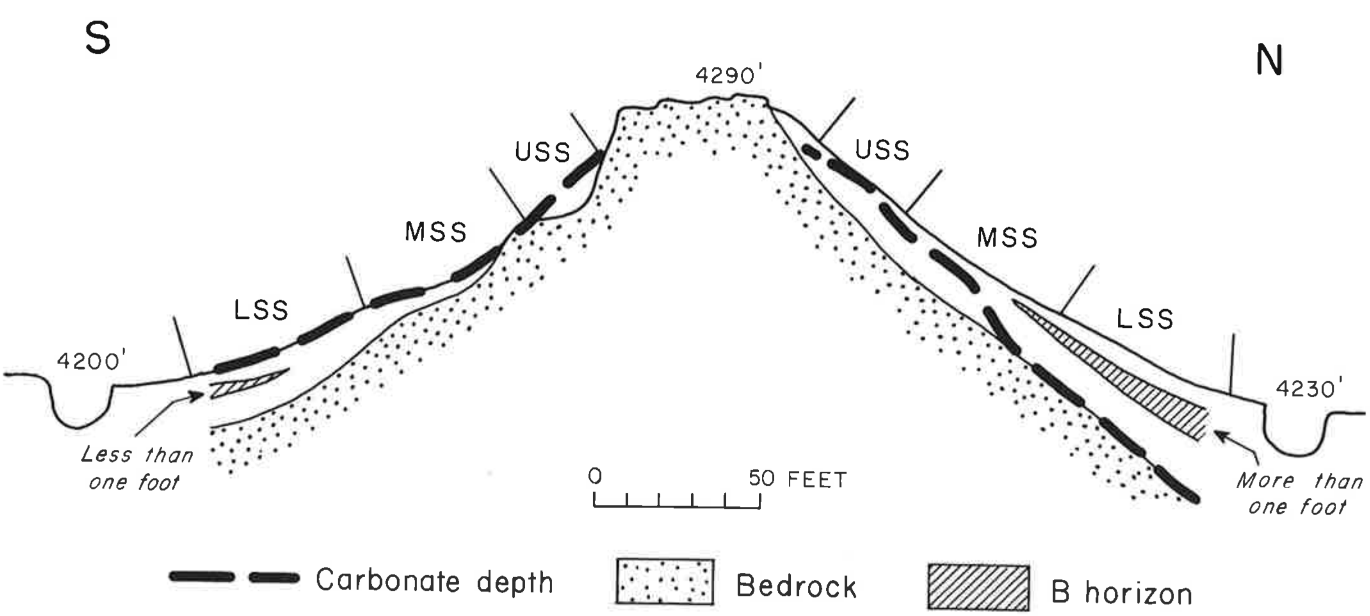
The difference in soil development is the result of a more moist microclimate on the north-facing slopes. The greater moisture on the north slopes has resulted in the formation of a thicker vegetative cover and, consequently, in less soil erosion than on the south slopes. While soil scientists and foresters who have worked on the Pine Ridge have generally accepted that these differences exist, this study was designed to begin quantifying such differences. Further study of the physical and chemical characteristics of some of the soil pedons (soil profile units) in the Pine Ridge is planned.

The Pine Ridge is an eroded, tree-covered escarpment in the semi-arid climate of northwestern Nebraska. It is the boundary of the High Plains physiographic province to the south and the White River-Hat Creek drainage basin to the north. The ridge forms an arc about 65 miles long from the Wyoming border through Nebraska and into South Dakota. Elevation along the escarpment in Nebraska changes from about 3,800 feet at the eastern end in Sheridan County to about 5,000 feet at the western end in Sioux County. Changes in elevation from the base to the top of the escarpment are about 500 to 600 feet.

A series of transects were run on the north and south slopes at selected sites in Dawes, Sheridan and Sioux counties. The transects were run straight up and down the slope, and the sampling interval was 20 feet. The landscape designation was sideslope, which was broken down into upper sideslope, mid-sideslope and lower sideslope. Soil properties recorded were depth to bedrock, aspect, horizon development, horizon thickness, depth to carbonates, slope and texture.

The soil on the north slopes exhibited greater mean depth to bedrock, greater mean depth to carbonates—evidence of more intense leaching—and a larger percentage of Bt horizons—evidence that more soil development has taken place on the north slopes. By field hand-texturing, the clay increase in the Bt horizon seemed to meet the requirements for argillic horizons; however, very few of these horizons showed physical evidence of illuviated clay deposition, so they were called cambic instead of argillic. An argillic horizon is a diagnostic illuvial subsurface horizon characterized by the accumulation of silicate clays. A cambic horizon is one that has been changed by soil-forming processes.

Several factors may have influenced the different development of soils on north and south slopes. The aspect and the thick ponderosa-pine cover cause snow to accumulate in deep drifts on the north slopes. North slopes are sheltered from direct sunlight much of the winter, and the snowcover melts at a much slower rate than it does on the south slope. This longer period of moisture saturation and additional moisture from snow accumulation would explain the more intense leaching of carbonates on the north slopes. These factors also may be influencing the development of B horizons on the north slopes. In addition, the thinner vegetative cover on the south slopes would give less protection against




*Cross section of typical Pine Ridge slopes, showing B horizons, carbonate depth and bedrock.*

soil erosion. The higher erosion rates would result in shallower soils on the south slopes than on the north.

North and south of the Pine Ridge are areas of loessial soils. Small areas of loessial soils were found in the Pine Ridge during the soil survey of Dawes County. Loessial materials are deposited in a pattern similar to that of snowfall; this could also be a factor in the differences between north and south slope soils. I found no loess-like material on the south slopes or on the upper sideslope position on the north slopes. In places I did find loess-like material on the mid-sideslope and lower sideslope positions on the north slopes.

When the data were analyzed on the basis of slope subunit, it was found that the only subunit with a high percentage (71.4 percent) of Bt horizons was the lower sideslope on the north slopes. The depth to carbonates was also greatest in this position.

The soils with Bt horizons varied, with the field-estimated particle-size classes being fine-silty, fine-loamy and coarse-silty. Depth to bedrock in these soils also varied, ranging from approximately 20 inches to greater than 60 inches. If the Bt horizons were classified as argillic, then the fine-silty soils would fit into the Keith, Alliance and Mace series. They are all loessial soils, fine-silty Aridic Argiustolls. The difference between them is depth to rock, which is greatest for Keith; Alliance has rock at a depth of 40 to 60 inches; Mace has rock at a depth of 20 to 40 inches. The fine-loamy and coarse-loamy soils did not fit into any established series.

# *Windbreak Technology Explored at Symposium*

**While windbreaks apparently help crops conserve** moisture and increase yield—moderating extreme weather such as drought and cold—determining the exact conditions and mechanisms with which they do this has become the biggest challenge facing researchers of the effects of shelter, said an organizer of the International Symposium on Windbreak Technology held in Lincoln June 23-27.

Other benefits of windbreaks documented at the conference were controlling wind erosion, providing wildlife habitat, protecting livestock from stress during harsh weather and reducing the amount of feed they need. Presentations on related areas documented the effectiveness of artificial windbreaks in dust control and establishment of vegetative cover and the energy-saving properties of urban trees.

In Nebraska, for instance, 139,000 acres of windbreaks produce about $28,800,000 in annual value for the state and create 1,175 jobs, according to the presentation of Thomas Schmidt, forest resource planner for the Nebraska Forest Service of the NU Institute of Agriculture and Natural Resources.

In all, about 350 participants from 14 countries, including China, Australia, New Zealand, Denmark and some African and Middle Eastern nations, convened at the Hilton Hotel to explore a variety of topics related to shelter. On the last day, discussion groups generated lists of areas needing further research.

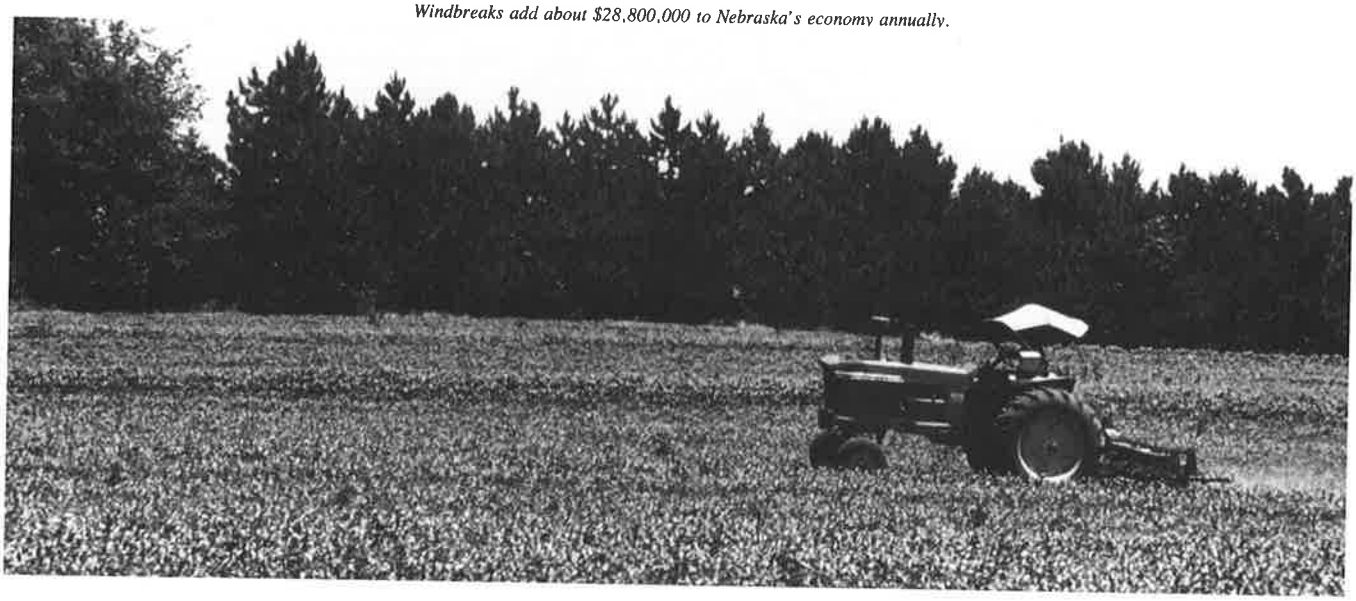
Symposium organizer Jim Brandle, associate professor of forestry at the IANR, said that he was especially impressed with the amount of discussion generated between people who were research-oriented and those who were application-oriented. He also noted that the conference generated a bibliography of more than 3,000 references, more than doubling anything he had seen previously. In addition, this summer one of the symposium's co-sponsors, Elsevier Press of Amsterdam, the Netherlands, will publish a book of about 35 chapters that compiles the presentations of the major invited speakers.

**"I think shelter has a role to play in almost every kind of environment, but the roles are different; depending on the environment, the results are different."**

**—Brandle**

"I think shelter has a role to play in almost every kind

*Windbreaks add about $28,800,000 to Nebraska's economy annually.*



Nebraska Statewide Arboretum

of environment, but the roles are different; depending on the environment, the results are different,'' Brandle said.

In his presentation, ''Response of Winter Wheat to Shelter in Eastern Nebraska,'' Brandle said, ''Windbreaks tend to moderate the extremes of cold, dry, windy conditions, and/or hot, dry, windy conditions. In years when these conditions are most prevalent, windbreaks have their greatest effect.''

Brandle noted that when wheat was harvested in the years 1976 through 1982, average yields were 14.6 percent greater in sheltered areas than exposed areas. However, results varied from a 44 percent decrease in yield in sheltered areas in 1982, a year of above-average moisture that contributed to an outbreak of wheat scab, to an increase of 128 percent in 1984.

Brandle said one of the most discussed issues emerging from the conference was: how does shelter affect plant water-use efficiency? This was addressed primarily in Gylan Dickey's research on ''Improved Crop Water Use Efficiencies with Windbreaks,'' and in the work of Jack Davis and John Norman on the ''Effect of Shelter on Plant Water Use.'' Dickey is an irrigation engineer with the U.S. Soil Conservation Service Midwest National Technical Center in Lincoln. Davis is a doctoral student in forestry, and Norman is an agronomist, both with the IANR.

Dickey offered a method to convert changes in crop yield to an estimated equivalent moisture that was site and crop specific and could be applied anywhere with a minimum of data, he said. By using data comparing percentage reduction in evapotranspiration to percentage reduction in crop yield (relative to total potential evapotranspiration), the method eliminates the major effects of climate and establishes one curve for a specific crop no matter where it is grown, he said. In one experiment on grain sorghum grown in North Platte, he documented an equivalent moisture conservation of 2.1 inches in sheltered over open areas.

Davis and Norman said that ''shelter is more than just a reduction of windspeed. Complex changes in microclimatological profiles of temperature and humidity are also involved.'' In reviewing the existing literature on the effects of shelter, Davis pointed out that shelter is a mosaic of effects. While certain yield increases have been documented as a result of shelter, the connection to water-use efficiency is less direct, he said. Rather than lumping various efficiencies together, Davis said, he was interested in reviewing how sheltered and unsheltered plants use water if they have the same amount available. Theoretically, the effect of greater humidity in a sheltered area means that both sheltered plants and unsheltered plants perform photosynthesis at the same rate, but that the sheltered plants transpire less and have a higher rate of carbon fixation relative to water loss, he said. The sheltered plants, therefore, are ''uncoupled'' from the larger, drier macroclimate and respond to the the more humid microclimate created in the quiet zone of the windbreak.

Integrating the perspectives of three presentations on water use—Dickey's, Davis and Norman's and that of John Grace, a Scottish researcher who found that mechanical injury by wind to leaf epidermal cells may increase conductance of moisture—will be one of the biggest challenges facing windbreak researchers, Brandle said.

Held under the auspices of the Great Plains Agricultural Council Forestry Committee, the symposium was sponsored by the USDA's Soil Conservation and Forest services, as well as various subdivisions of the IANR, including the Agricultural Research Division, the Conservation and Survey Division, the Cooperative Extension Service, the Department of Forestry, Fisheries and Wildlife, International Programs, the Nebraska Forest Service and the Nebraska Statewide Arboretum. Dave Hintz, national windbreak forester for SCS at the technical center in Lincoln, also was a key organizer. In all, nearly 30 different public and private agencies and about 25 corporate sponsors and contributors provided financial support.

# Urban ''Windbreaks'' Cut Home Heating and Cooling Costs

**Just as rural windbreaks moderate the extremes of** climate around crops and farmsteads, so do urban ''windbreaks,'' commonly known as landscaping, reduce home heating and cooling costs by moderating the microclimate around the home, according to a horticulturist at the University of Nebraska Institute of Agriculture and Natural Resources.

Although recognizing this effect was as easy as remembering the plantings of early prairie home builders, getting this message to the people has resulted in a multi-faceted public education and assistance campaign by the Nebraska Statewide Arboretum, said its education director, Luann Finke, at the International Symposium on Windbreak Technology June 24 at the Hilton Hotel in Lincoln.

Begun in 1980, Nebraska's ''Plant Two Trees'' program was taken over by the Statewide Arboretum in 1985, becoming the ''Plant Two Trees for Energy'' program. Funded in part by a U.S. Department of Energy grant and oil overcharge money, this campaign focused on the energy-saving potential of tree planting, she explained.

Well-placed trees can reduce a home's energy requirements by up to 40 percent, according the arboretum's slide-tape presentation, ''Conserve Energy . . . Naturally,'' designed to take this message to community groups across the state.

Other benefits of energy-saving landscaping quantified in the presentation were:

—Increasing the average value of the home by 6 to 15 percent.

—Creating a pocket of dead air around the house that reduces air infiltration—air leaking out through doors and windows or through cracks around them. Responsible for 20 to 33 percent of total heat loss, at times as much as half, this is the primary source of heat loss.

—Cutting the energy required to cool a mobile home by 75 percent compared with an unshaded site. This figure resulted from a Pennsylvania experiment with a grove of deciduous trees.

—Increasing the efficiency of an outdoor air conditioning condenser by about 3 percent by shading it with trees.

Benefits less easily quantified include noise and pollution control, separation of different land-use areas and aesthetic benefits.


*An isolated sapling in a suburban development is a start toward energy-efficient landscaping, but this tree, even when grown, cannot do the job alone. Heating and cooling savings increase as landscaping becomes synergistic.*


*A combination of large trees and smaller trees and shrubs provide year-round energy savings, cutting home heating and cooling costs. Deciduous trees provide shade in summer and then lose their leaves to let in sunlight for passive solar heating in winter.*

At this point, Finke said, the arboretum had a product that conserved energy, and a message about it, but it had no way to get this message out to people of the state. However, by the beginning of 1986, the focus of the Plant Two Trees for Energy program had grown from an educational and promotional one to a plan of direct action with local communities, which had begun asking for support to meet their planting goals.

This year, responding to requests from communities wanting help developing educational landscaping plans, the arboretum obtained a 3-year grant for $500,000 from the Peter Kiewit Foundation to help meet plant material costs. To obtain the grants, the communities are to supply private, matching funds on a dollar-for-dollar basis.

Other provisions of the Kiewit grant include:

—The money can be distributed throughout the state, excluding the metropolitan areas of Lincoln and Omaha.

—Grants range from $1,000 to $62,500, according to population.

—The newly instituted Center for Landscape Stewardship, an outreach wing of the Statewide Arboretum, will provide assistance in project planning, educational program development and maintenance planning. The center has been set up in cooperation with the Nebraska Forest Service of the IANR and the NU College of Architecture.

Small communities outstate are particularly well-suited for this kind of program because they rarely have a paid landscape architect, nor do they have the money to hire a consultant, Finke explained. And it seems to meet their needs, she added, based on the first-round approval of about $185,000 in grants.

Interested communities should contact the Nebraska Statewide Arboretum for additional information, she said.

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## *New publications and maps from the Conservation and Survey Division*

**Maps:**

**—Aeromagnetic Map of Nebraska, 1985** (1:1,000,000): Ray Burchett; $1

**—Center-Pivot Irrigation Systems in Nebraska, 1985** (1:1,000,000): Gene Murray, project leader; $.50

**—Geologic Bedrock Map of Nebraska,** (1:1,000,000): Ray Burchett; $2

**—Groundwater Maps, 1985** (Location of registered irrigation wells, 1985; Significant rises and declines in groundwater levels, 1985; both for Nebraska, 1:4,000,000): Darryll Pederson; free

**Publications:**

**—The Groundwater Atlas of Nebraska:** Robert Kuzelka and Darryll Pederson, project leaders; $2

**—Groundwater Levels in Nebraska, 1985:** Michael Ellis and Darryll Pederson; $4

**—Nebraska Mineral Operations Review, 1985:** Ray Burchett; free

**—Water-Quality Monitoring Transects in an Irrigated Area of the Eastern Sand Hills, Nebraska:** Dennis Lawton; $3.50

# Selected Publications and Maps Related to the Nebraska Panhandle

Educational Circulars

**—Geologic History of Scotts Bluff National Monument:** R.K. Pabian and J.B. Swinehart II (1979); $1

**—Geologic History of Ash Hollow Park, Nebraska:** R.F. Diffendal, Jr., R.K. Pabian, and J.R. Thomasson (1982); $2

Geologic Survey Publications

**—Correlation of the Formations of the Laramie Range, Hartville Uplift, Black Hills, and Western Nebraska:** G.E. Condra, E.C. Reed, and O.J. Scherer (1940; rev. ed., 1950); 50¢

**—New Members of the Gering Formation (Miocene) in Western Nebraska Including a Geological Map of Wildcat Ridge and Related Outliers:** C.F. Vondra, C.B. Schultz, and T.M. Stout (1969); 75¢

**—Tertiary Stratigraphy of the Niobrara River Valley, Marsland Quadrangle, Western Nebraska:** Daniel Yatkola (1978); $3

Water Survey Papers

**—Inventory of Irrigation Water Use, Box Butte County, Nebraska–1981:** D. Lawton and L. Teahon; $3.50

**—Groundwater Geology of Banner County, Nebraska:** F.A. Smith and V.L. Souders (1975); $1.50

**—Geology and Groundwater Supplies of Box Butte County, Nebraska, 1979:** V.L. Souders, F.A. Smith, and J.B. Swinehart II; $4

General Publications

**—The Pierre-Niobrara Unconformity in Western Nebraska:** Harold M. DeGraw (1975); 50¢

**—The Succession of Late-Cenozoic Volcanic Ashes in the Great Plains:** John Boellstorff (1976); 50¢

**—The Dynamic Holocene Dune Fields of the Great Plains and Rocky Mountain Basins, U.S.A.:** Ahlbrandt, Swinehart and Maroney (1983); $1.25

**—Uranium Geochemistry in Groundwater from Tertiary Sediments:** Roy F. Spalding, A. Douglas Druliner, Lowell S. Whiteside and Arthur W. Struempler (1984); 50¢

**—Characteristics, Age Relationships, and Regional Importance of Some Cenozoic Paleovalleys, Southern Nebraska Panhandle:** R.F. Diffendal, Jr., J.B. Swinehart, and J.J. Gottula (1985); 50¢

**—Cenozoic Paleogeography of Western Nebraska:** James B. Swinehart, V.L. Souders, Harold M. DeGraw and Robert F. Diffendal, Jr. (1985); $1

Soil Survey Reports

Available for Dawes, Deuel, Box Butte, Kimball and Scotts Bluff counties (Price varies)

Deep Well Maps (Gas and Oil)

Available for Banner, Cheyenne, Kimball, Morrill, and Scotts Bluff counties, and Areas VII and X (1:62,500); each $1

Maps and Charts

**—Geology of the Pre-Tertiary (Principally Pre-Chadron) Surface in Western Nebraska, 1968** (1:500,000); each 45¢

**—Geologic Map of the North Half of the Marsland 15-Minute Quadrangle, 1976** (1:38,000); each 50¢

**—Quadrangle Soil Maps, 1981,** color print on USGS 1° × 2° base (1:250,000); each $1

**—Configuration of Water Table: 1979,** printed on USGS 1° × 2° base (1:250,000); each 50¢

**—Base of Principal Aquifer: 1980,** printed on USGS 1° × 2° base (1:250,000); each 50¢

**—Thickness of Principal Aquifer: 1980,** printed on USGS 1° × 2° base (1:250,000); each 50¢

**—Groundwater Nitrate-Nitrogen Concentrations: 1980,** color print on quadrangle base (1:250,000); each 50¢

All of the above maps are available for the Alliance and Scottsbluff quadrangles

U.S. Geological Survey Topographic Maps

Available for areas in the Panhandle:
7½′ (1:24,000); each $2.50
15′ (1:62,500); each $2.50
1° × 2° (1:250,000); each $4

Prices for publications and maps listed in this newsletter do not include mailing and handling costs. Please add $1 if a publication or a folded map is requested, $1.50 for a map in a mailing tube. If first-class mail is desired, the prices mentioned above are doubled.

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